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(54) Title: AN APPARATUS AND A METHOD FOR TREATING EMULSIFIED LIQUIDS		
(57) Abstract		
<p>An apparatus for treating emulsified liquids using a minimum of energy, comprising a tube heat exchanger (4) placed in an evaporation chamber (1). A sump (3) for emulsified liquids is placed under the tube heat exchanger (4). A compressor (36) leads vapour from the evaporation side of the heat exchanger to the condensing side while it simultaneously gives off a certain amount of energy to the vapour. The apparatus is working according to the vapour compression principle. When operating the apparatus the difference of the temperature between the evaporation and condensation is kept within a narrow temperature range, just as the pressure differences between the sump and the evaporation chamber are kept within a narrow pressure range. Accordingly, it will be possible to supply a small amount of energy in order to perform an evaporation, compression as well as a condensation.</p>		

+ DESIGNATIONS OF "SU"

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AN APPARATUS AND A METHOD FOR TREATING EMULSIFIED LIQUIDS

The present invention relates to an apparatus and a method for treating and separating emulsified liquids. Thus the invention relates to a method for cleaning and separating emulsified liquids, especially cooling/lubricating oil emulsifications, degreasing water, oil containing waste water, waste water from laundries, from the food production, solvents and the like, said method comprises vapour compression in which the emulsified liquids are boiled in a sump, and in which the vapours produced are compressed in a compressor leading the vapours into a heat exchanger, in which they are cooled and condensed, and in which the heat released by the condensation is transferred to the emulsified liquid, said heat exchanger is placed in an evaporation chamber. The separation of the specific substances and water or solvents is often required due to recycling of the water and/or for reducing the costs of transportation and destruction of the waste water.

The industry uses a number of various solvents, e.g. for degreasing and cleaning. Besides, the engineering industry is using cooling/lubrication oils mixed with water. These often enter into a heavy emulsification with the water which means that the emulsified liquid is very difficult to separate. When the said agent for degreasing, cleaning, cooling and lubricating has been used a number of times, it is saturated with dirt, heavy metals, moisture, and other impurities. Therefore, a concentration or a destruction of the agent in question is required.

Usually the concentration of solvents is performed by means of a simple boiling followed by a subsequent cooling, typically by using water as cooling agent. This method is disadvantageous as it is energy consuming.

In recent years the concentration of cooling/lubricating oil emulsifications has been impeded, because softeners are added to the cooling/lubricating agents thus the oils emulsify heavily with water. Consequently, a subsequent concentration is very difficult.

Besides boiling, a chemical method for separating emulsified liquids is known. However, the chemical separation is an expensive method requiring an exact adaption of a demulsifying agent and usually it will only be economical at concentrations lower than 1%.

Yet another method for concentration of solvents is known, viz. the so-called ultra filtration, in which the specific elements are separated by filtration. This process is also expensive, and moreover problems as to clogging of the specific filters arise and consequently the method is subjected to uncertainty and requires a demand for frequent supervision.

As it appears from the above several attempts have been made in order to provide apparatus and methods for treating emulsified liquids, but so far these have been associated with disadvantages.

It is the object of the present invention to remedy the disadvantages associated with the known processes and to provide a method in which the separation is established by means of a boiling process and a subsequent cooling and in some cases by means of gravitational separation, and by subsequent cooling using a minimum of energy.

According to the present invention this object is achieved by the method described in the preamble of the specification and which is characterized in that the temperature difference between the evaporation and the condensation is kept within a narrow temperature range of about 0.5-6°C, that the level for this temperature range is determined on the basis of the desired distillate, that the temperature level is controlled by a thermostat filled with a liquid identical with the desired distillate and that the vapour compression is optionally combined with gravitation separation of the emulsified liquids.

Depending on the boiling point of the specific elements in the polluted liquid the pressure and the temperature are regulated in the evaporation chamber. The polluted liquid is heated by means of the heating element, e.g. to 100°C and this temperature is maintained by pre-heating the liquid in a heat exchanger and by adding extra heat - if necessary - by means of the said heating element.

Heating in the sump may be provided by means of an electric heating element, and the heat exchanger used may preferably be a tube or plate heat exchanger of which the inner and outer tube side are connected to the compressor ensuring the transfer of the vapour and the pressure increase. The emulsified liquid is transferred from an external source

in the sump. This may e.g. take place via a heat exchanger. From the sump the emulsified liquid is pumped up into the top of the tube heat exchanger, from which it can flow down through the tube heat exchanger as a liquid film obtaining an evaporation. In some cases, during the transfer from the sump to the top of the tube heat exchanger a partial flow can be led into a gravitation separator containing a float being able to float on one of the liquids but not on the other, e.g. on water but not on oil. This float controls a solenoid valve leading the partial flow back to the system after having drawn off the separated liquid, e.g. oil from the top of the gravitation separator. This separation process may be very fast due to the high temperature of the liquid and the corresponding low viscosity of oil.

A supervision of the level of the condensed liquid may preferably be made in the evaporation chamber. Also the measurement of the pressure and the temperature of the condensed liquid is made in the evaporation chamber with a view to control the progress of the procedure.

The condensed liquid can be led through a coalescer before it is drained out. This ensures that any oils having been transferred with the vapour are separated. Furthermore, the apparatus may comprise a density metering device that releases a small amount of the concentrated waste water if the ion concentration and the corresponding density become too high causing increased boiling temperature.

The method will preferably be effected in a unit provided in an insulated chamber.

The circulation pump transfers the heated liquid up into the uppermost part of the evaporation chamber so that it flows down into the tube heat exchanger on the inner side of the tubes as a liquid film. By means of the compressor the pressure is increased, and hereby the vapour is supplied with energy in the form of pressure and heat. The latter causes an energy flow in the tube heat exchanger and provides an evaporation on the inner side of the tubes. Now the energy circle is complete.

Keeping the evaporation temperature difference and the condensation temperature within a very narrow range, e.g. 100-102°C, substances

with a lower boiling point will not condense but be vented in the vapour phase and condensed later in a condensation container from which it may be drawn off as a liquid for destruction or recycling.

5 Substances with a higher boiling point and solid particles will not evaporate. They remain in the liquid in the sump. When reaching a predetermined level of concentration a draw-off is effected. Alternatively, such substances may be separated by the gravitation separation and become almost completely concentrated. Concentration of the waste
10 water takes place continuously in the sump.

It is important to keep the narrow temperature range in order to minimize the energy consumption. The ion concentration in the waste water may effect the condensing temperature. Thus the density may be monitored by means of a density metering device. Through a solenoid valve
15 in the sump it is possible to release a small amount of the concentrated waste water thereby regulating the ion concentration and thereby keeping the evaporation and condensing temperature within a required range.

20 A method according to the present invention provides a safe separation of liquids in a distillate and undesired liquids and solid substances. It is also a very energy-saving method, as the power factor will be extremely high up to 20-80 depending on the capacity. With the power
25 factors mentioned the price for treating 1 ton polluted waste water typically ranges from DKK 2.50 to DKK 10.00.

The principle used is usually referred to as mechanical vapour compression, and it is disclosed in Danish Patent Nos. 68,529 and 78,060 filed
30 by Mr. Rolf Andersen. It has been used for treating radioactive waste water, for producing drinking water out of sea water, as well as for concentrating brine, exclusively for use in very large complicated systems. The method according to the present invention may be effected with an apparatus of a very simple design and suited for use in the
35 industry where the demands for simple and easy-to-service constructions are large as well as the investment costs are kept at a minimum level.

Besides, the method may be used for separating substances with diffe-

rent boiling points within a very narrow temperature range, as the present technology ensures that the evaporation and the subsequent condensation is effected within a very narrow temperature range, typically ranging from 1-2°C. Thus substances with higher boiling points in the evaporation phase will not evaporate and at the subsequent condensation, substances with lower boiling points will not condensate and may be blown off separately, and in this way they are separated.

In some cases it is optimal to combine the vapour compression principle with the gravitation separation principle in order to obtain an optimal separation and a fast process at the relatively high temperature and the corresponding low viscosity of oil.

The invention also relates to an apparatus for use in the above-mentioned method. The apparatus operates according to the vapour compression principle optionally combined with a gravitation separation and of the type which comprises means for boiling the emulsified liquid, means for cooling and condensing the vapours produced, which boiling and condensing means are constituted by a heat exchanger placed in an evaporation tank comprising a top and a sump being connected to a pipe including a circulation pump and in which the evaporation and condensation take place whereby the condensed liquid is collected in an evaporation chamber, while the vapour is driven from the evaporation side of the heat exchanger to the condensation side by means of a compressor delivering a certain amount of energy to the vapour, characterized in that the compressor is provided for being controlled according to signals from pressure switches measuring the pressure in the evaporation chamber and in the sump and according to signals from a thermostat being connected to the sump and being filled with a liquid identical with the desired distillate, and that the sump and the evaporation chamber are supplied with draining-off means.

The apparatus may be equipped with a gravitation separator connected to a branching of the pipe connecting the sump and the top of the evaporation chamber and being provided for concentration of a partial flow. The apparatus may also comprise a coalescer connected to the distillate outlet from the evaporation chamber.

Furthermore a density regulator can be included to control the ion

concentration in order to keep the boiling range within certain limits.

5 This apparatus which preferably comprises a vertical tube heat exchanger and which preferably is placed in an insulated chamber may be produced as a compact unit in which the method can be practiced in order to obtain the desired energy saving.

10 In a special compact version the apparatus can be designed with the evaporator chamber and compressor as an integrated unit. This is especially useful in apparatus with smaller capacities.

DESCRIPTION OF THE DRAWING

The invention will now be further explained with reference to the accompanying drawing, wherein

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Fig. 1 is a schematic view of the apparatus according to the invention,

Fig. 2 is a schematic view of the apparatus according to the invention with a humidity-drying filter,

20 Fig. 3 illustrates the lowermost part of the evaporation tank illustrated in Figs. 1 and 2,

Fig. 4 is a schematic view of a further embodiment of the apparatus according to the invention with a gravitation separator and a density regulator, and

25 Fig. 5 is a schematic view of the apparatus according to the invention with an evaporator and a compressor as an integrated unit.

30 The three embodiments illustrated have much in common and accordingly, identical or corresponding elements are designated with identical reference numbers in the different Figs.

35 The apparatus illustrated in Fig. 1 comprises an evaporation tank 1, consisting of an outer shell 2, a cover 16, and a sump 3. These three parts are collected by flexible bands 14 and 15. In the shell 2 a tube heat exchanger 4 is placed consisting of vertically placed tubes 40 with a diameter of 6-25 mm being welded onto an upper cover plate 5 and a lower cover plate 6. The tubes 40 are led about 50 mm through the upper cover plate 5 ensuring a correct and even distribution of a

polluted liquid 41 to be treated (explained below).

5 The cover 16 is provided with a distribution ring 17. This distribution ring ensures that the polluted liquid 41 pumped from the sump 3 by means of the circulation pump 29 is evenly distributed to all the tubes 40.

10 The liquid 41 is fed from the sump 3 by means of a circulation pump 20 via a heat exchanger 18. In front of the circulation pump 20 a stop valve 21 is placed preventing reflux during standstill-periods.

15 The polluted liquid 41 is elevated to e.g. 100°C - in case of liquids with water as main element - by means of an electrical heating element 25. The temperature of the liquid 41 is controlled and supervised by means of a thermostat 26. The pressure in the sump 3 is controlled and supervised by a pressure switch 28. The pressure in the evaporation tank 1 is controlled and supervised by a pressure switch 33.

20 The thermostat 26 and the pressure switches 28 and 33 are specially designed with a large diaphragm in order to meter very small differences. This is necessary in order to ensure a correct control of the boiling point and the corresponding vapour pressure for a distillate 44 in question. The interior of the thermostat 26 is filled with a reference liquid identical with the distillate 44. I.e. water to be
25 distilled, the reference liquid is also water. The pressure switches 28 and 33 are designed so that an automatic adjustment takes place in case the atmospheric pressure changes. This is necessary in order to ensure a registration and adjustment of the correct vapour pressure during evaporation. In the sump 3 a conductivity meter 43 is placed
30 supervising the contents of ions in the liquid 41. In case the concentration is too high a solenoid valve 42 is opened for draining off the concentrated liquid 41 from the bottom of the sump 3.

35 If the liquid 41 contains large amounts of oil and oily liquids lighter than the distillate 44 these will float on the surface of the liquid 41. Draining off this oil is controlled at the level controller 27 and the solenoid valve 19.

The mode of operation and the special construction of the sump 3 in

this connection are illustrated in Fig. 3 and will be described later.

5 In the evaporation tank 1 a level controller 30 is placed to supervise and to secure the draining off the distillate 44 via a solenoid valve 39 and a heat exchanger 18. The heat exchanger 18 ensures that the heat removed by draining off the distillate 44 is transferred to the liquid 41 which is led into the sump 3, so that the heating element 25 must supply a minimum of power only.

10 When deactivating the apparatus and switching off the power the solenoid valve 39 ensures that atmospheric air is drawn into the evaporation tank 1 and thus a pressure compensation is established. In operation the temperature in the evaporation tank 1 may be above 100°C and during the cooling in connection with a deactivating of the apparatus
15 a vacuum could arise in the evaporation tank 1 so that it might collapse and be damaged.

The evaporation tank 1 is provided with the pressure switch 33 supervising the pressure and ensuring the blowing-off of the non-condensable gases via a solenoid valve 32 to a condensation chamber 23, in
20 which the gas condensates due to a low temperature. The condensation chamber 23 is provided with a throttle valve 24 which at one hand empties non-condensable gases from the condensation chamber 23 and, at the other hand, ensures a continuous emptying of non-condensable gases
25 from the evaporation tank 1 via a throttle valve 31. An emptying of the condensation chamber 23 is effected by means of a manual stop valve 22.

A mechanical safety valve 34 is mounted in the evaporation chamber 1
30 for extra security. A vapour compressor 36 being driven by an electric motor 37 via a shaft 45 is connected to the sump 3. In order to secure that oil drops are carried along from the sump 3 through the vapour compressor 36 a drop catch 38 is arranged in front of the inlet of the vapour compressor 36.

35 The outlet of the vapour compressor 36 is connected to the upper part of the shell 2 being connected to the outer part of the tube heat exchanger 4. The evaporation tank 1 with the vapour compressor 36, control means, and solenoid valves are encapsulated in an insulated cabi-

net 35 in order to maintain the correct working temperature.

5 In principle the apparatus illustrated in Fig. 2 is identical with the apparatus shown in Fig. 1, however, with the exception that a humidity-drying filter 47 is placed between the vapour compressor 36 and the drop catch 38 in order to absorb humidity when the apparatus is used for treating e.g. solvents or refrigerants where the demands to the level of residual moisture are extremely high.

10 In this version a standard tube size as shell 2 is used and a larger dimension for the tubes 40 are used, whereby a reduction in the manufacturing costs is obtained, and simultaneously the demands for an increased working pressure may be met.

15 This version is also suitable for small capacities of 5-10 l/h for liquids with water as main element.

Fig. 3 illustrates the sump 3 being so embodied that separation of oil from the liquid is optimized.

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After evaporation of the distillate 44 the concentrated oil and water drip down onto a hopper 7 ending in a wide tube 48. Owing to the differences in specific gravity the oil will float and accumulate in the upper part of the wide tube 48.

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When the level controller 27 with a float 46 indicates low level of liquid, liquid 41 is added until an upper level is reached. Simultaneously, with the initial filling the solenoid valve 19 is opened, so that the oil accumulated in the wide tube 48 flows over the edge of an inner tube 10 and out of the sump 3. When the filling is completed the solenoid valve 19 is closed again.

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If salts are concentrated in the sump 3, this is registered by means of a conductivity meter 43 signalling the opening of the solenoid valve 42 which closes again by means of a timer which is not shown.

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The apparatus is used in the following manner. The polluted liquid 41 to be treated is added by starting a circulation pump 20, which is controlled by the level controller 27, so that the sump 3 is filled

until a predetermined level.

Depending on the boiling point of the distillate 44, e.g. water, the liquid 41 is in this case heated in the sump by means of the heating element 25, e.g. to 100°C. When this temperature is reached the vapour compressor 36 is started by means of the thermostat 26 and the pressure switch 28, which have to register a pressure and a temperature corresponding to the boiling point temperature and the boiling point pressure of the distillate 44.

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If this is not the case, e.g. because a liquid having a lower boiling point being mixed with the liquid 41, the pressure will be sufficiently high but the temperature will be too low. If this is the case the vapour of the lower boiling liquid is led via the compressor 36 to the evaporation tank 1, from which it is led to the condensation chamber 23 through the solenoid valve 32 being controlled by the pressure switch 33 and the thermostat 26 in combination.

15

When the pressure and the temperature in the sump 3 correspond to the distillate 44 which is to be separated, the vapour compressor 36 is started, and the vapour is led from the sump 3 to the evaporation tank 1.

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When activating the apparatus the circulation pump 29 is started, so that the liquid 41 is transferred to the cover 16 from where, via the diversion ring 17, so that it is led down into the tubes 40 as a liquid film so that an optimal heat-transfer and thus an optimal evaporation is obtained.

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The vapour that is carried along from the sump 3 passes through a perforated screen 8 in order to collect any drops. Furthermore, drops may be collected in the drop catch 38 placed in front of the compressor 36. The compressor 36 supplies energy to the vapour so that the temperature of the vapour is increased slightly, for water vapour typically from 100 - 102°C. This difference in temperature is to be maintained as low as possible in order to optimize the apparatus. The whole unit is arranged inside the insulated cabinet 35 in order to reduce heat loss to the surroundings.

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The vapour driven by the compressor 36 is condensated on the outer side of the tubes 40 and is collected in the bottom of the evaporation tank 1, and can be drained off as a condensate 44, when a desired level is reached. The level controller 30 controls the solenoid valve 39 that drains off the distilled 44 through the heat exchanger 18 ensuring that the accumulated heat in the distillate 44 is given off to the liquid 41 to be treated.

The apparatus illustrated in Fig. 4 shows an embodiment where the vapour compression and the gravitation separation principles are combined in one unit.

A partial flow is extracted just after the circulation pump 29 and is fed through a restrictor 58 into a gravitation separator 48 consisting of a tube 55 with top and bottom. In this tube 55 a float 49 is placed which float being supplied with a ring magnet 50 at the top. Both the float and the ring magnet surround a tube 62 in which a reed relay 51 is placed. When passing the reed relay 51 the ring magnet will activate this and control the open/close function of a solenoid valve 53 which is connected to the reed relay by a conduit 52. The float 49 is provided so that it floats in water but not in oil. Accordingly, the oil which has been separated as a result of gravitation rises to the surface and may subsequently be skimmed off through a connection pipe 54 as completely concentrated oil.

Using the gravitation separation method of the invention means that only a small amount or no oil is to be drained off through the solenoid valve 19 (not shown in Fig. 4).

When draining off the distillate 44 a mixture containing a small amount of residual oil may occur. Such mixture has been led through the vapour compressor 36 and is condensed together with the distillate 44.

To secure that this oil is separated, coalescing means 61 has been installed in front of the outlet via the solenoid valve 39 and the heat exchanger 18. The coalescing means 61 is provided in the form of a tube 60 with closed top and bottom. About half of the tube 60 has been filled up with an insulation material 59 of the type rockwool.

This insulation material has been arranged behind a perforated plate 69. The material 59 is temperature resistant and will collect the small oil drops that may be condensed together with the distillate 44, so that these drops get larger and come to the surface, from which they are skimmed off through an outlet 57 and an restrictor 63. A level regulator 56 controls the solenoid valve 39 depending on the presence of oil or water around the level regulator 56.

In certain cases a concentration of ions can occur resulting in an increased boiling temperature in the sump 3.

To control this a density regulator 68 is used consisting of a tube 64 with closed top and bottom, a float 66 with a permanent magnet 65 and a reed relay 67. The density regulator 68 is connected to the sump 3 and automatically controls the opening and closing of the solenoid valve 42' releasing a small amount of the liquid 41, and thus regulates the concentration thereof. The regulator 68 replaces the conductivity meter 43.

In this way it is possible to keep the ion concentration within a certain range and thereby the boiling point is also kept within a range securing continuous optimal operation of the unit.

The apparatus illustrated in Fig. 5 shows a special embodiment, in which the evaporator and compressor are produced in one unit. This version is particularly usable in small plants of capacities of 1-10 l/h.

The unit comprises an evaporation tank 71 containing an inner chamber 76 with a stirrer 73, a drop cover 80, a heating element 74, and an inlet 72 for filling of the polluted liquid 41. Between the inner chamber 76 and an outer chamber 70 a fan rotor 77 is placed. This is actuated by an electric motor 78, which also actuates the stirrer 73 on a common shaft 79.

The outer chamber 70 is also supplied with an outlet 75 for draining off the distillate 44.

The unit illustrated in Fig. 5 will be inexpensive, and it may be ma-

manufactured solidly. In addition the unit may form a separate component of the apparatus illustrated in Figs. 1,2, and 4.

5 The principle is the same as for the apparatus illustrated in Fig. 1 but with the difference that the inner and outer chambers 76 and 70 constitute the heat exchanger parts. The stirrer 73 will secure that vapours are giving free from the polluted liquid 41 and the pressure of the vapour is elevated by the fan rotor 77, so that it will condense in the outer chamber 70 in heat exchange with the inner chamber 10 76. The heating element 74 will elevate the temperature to the desired level, and in operation it will maintain the temperature dependent on signals from the thermostat 26 (not shown in Fig. 5).

15 Other controlling elements will be the same as illustrated for the apparatus according to Figs. 1,2, and 4.

20 It is essential to see the whole functional principle collectively, as evaporation, compression and condensation of the vapour take place simultaneously. The principle requires very little energy, as only the energy supplied by the compressor 36 and a number of minor losses are necessary for the process to work.

25 For oil containing waste water efficiencies of 40-80 are obtained, for solvents - for example R11 - efficiencies of 15-30 are obtained, for refrigerants - for example R12, efficiencies of 15-30 are obtained. This means that substantial savings may be obtained when treating liquids, solvents, etc.

30 For solvents - for example R11 - the typical operating conditions will be:

- capacity:	about 100 l/h
- evaporation temperature:	24°C
- condensation temperature	36°C
35 - evaporation pressure:	1027 mbar
- condensation pressure:	1343 mbar

For liquids with water as main element the typical operating conditions will be:

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- capacity: 100 l/h
- evaporation temperature: 100°C
- condensation temperature: 101°C
- evaporation pressure: 1013 mbar
- 5 - condensation pressure: 1052 mbar

The apparatus according to the invention can be used for liquids having high boiling point as well as liquids having low boiling point, and will be able to separate the individual components of the liquid
10 41 to be treated. The high boiling liquids will remain in the sump 3 and be drained off, while the low boiling liquids are drawn off with the vapour and led to the tube heat exchanger 4. However, they will not condense at the high temperature existing here. Such vapours will be led to the condensing chamber 23 in which they are condensed and
15 accordingly separated from the distillate.

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C L A I M S

1. A method for cleaning and separating emulsified liquids (41), especially cooling/lubricating oil emulsifications, degreasing water, oil
5 containing waste water, waste water from laundries, from the food production, solvents and the like, said method comprises vapour compression in which the emulsified liquids are boiled in a sump (3), and in which the vapours produced are compressed in a compressor leading the vapours into a heat exchanger (4;70,76), in which they are cooled and
10 condensed, and in which the heat released by the condensation is transferred to the emulsified liquid, said heat exchanger is placed in an evaporation chamber (1), characterized in that the temperature difference between the evaporation and the condensation is kept within a narrow temperature range of about 0.5-6°C, that the level for
15 this temperature range is determined on the basis of the desired distillate, that the temperature level is controlled by a thermostat (26) filled with a liquid identical with the desired distillate and that the vapour compression is optionally combined with gravitation separation of the emulsified liquids (41).
- 20 2. A method according to claim 1, characterized in that the compressor (36) driving the vapour from the evaporation chamber of the heat exchanger (4;70,76) to the condensation chamber maintains the pressure difference within a narrow range of about 20-200 mbar.
- 25 3. A method according to claims 1 or 2, characterized in that the temperature range is about 0.5-3°C for treating aqueous liquids and about 1-6 °C for treating solvent emulsifications and that the pressure range is about 20-120 mbar for treating aqueous liquids
30 and about 50-200 mbar for treating solvent emulsifications.
4. A method according to ant one of the preceding claims, characterized in that the non-condensable gases are vented automatically and condensed in a separate condensation chamber (23), that
35 a thermostat having a little difference is used for determing the temperature range (26), and pressure switches (28,33) having a little difference are used for determing the pressure range, and that the thermostat and pressure switches are supplied with bellows being in contact with the atmosphere, so that changes in the atmospheric pres-

sure are compensated for automatically.

5 5. An apparatus for use in a method according to any one of the preceding claims and of the type that operates according to the vapour
compression principle optionally combined with a gravitation separation and of the type which comprises means for boiling the emulsified
liquid (41), means for cooling and condensing the vapours produced,
10 which boiling and condensing means are constituted by a heat exchanger (4) placed in an evaporation tank (1) comprising a top (16) and a sump (3) being connected to a pipe including a circulation pump (29) and in which the evaporation and condensation take place whereby the condensed liquid is collected (at 44) in an evaporation chamber, while the vapour is driven from the evaporation side of the heat exchanger to the condensation side by means of a compressor (36) delivering a certain amount of energy to the vapour, c h a r a c t e r i z e d in that
15 the compressor (36) is provided for being controlled according to signals from pressure switches (28,33) measuring the pressure in the evaporation chamber and in the sump (3) and according to signals from a thermostat (26) being connected to the sump (3) and being filled with
20 a liquid identical with the desired distillate (44), and that the sump (3) and the evaporation chamber are supplied with draining-off means (19,22,39,42, 61).

25 6. An apparatus according to claim 5 and of the type in which the vapour compression is combined with gravitational separation, c h a r a c t e r i z e d in that a gravitation separator (48) is connected to a branching (58) of the pipe connection the sump (3) and the top of the evaporation chamber just after the circulation pump (29).

30 7. An apparatus according to claim 5 or 6, c h a r a c t e r i z e d in that the draining-off means (39,61) of the evaporation chamber comprises coalescing means (61).

35 8. An apparatus according to any one of claims 5-7, c h a r a c t e r i z e d in that the evaporation chamber, the sump (3), the compressor (36), the piping system and further auxiliary equipment are arranged in an insulated chamber (35), and that the draining-off means (19,22, 39,42,61) are embodied so that the concentrated liquid in the sump (3) and the distillate (44) in the evaporation chamber, the liquids sepa-

rated in the gravitation chamber (48) and the liquids separated in the coalescing means (61) are drained off automatically.

5 9. An apparatus according to any one of claims 5-8, c h a r a c t e r -
i z e d in that the thermostat (26) connected to the sump (3), and the
pressure switches (27,33) connected to the sump and the evaporation
chamber, respectively, are constructed for registration of very small
differences at the boiling point of the distillate and the correspond-
10 ing pressure of the distillate, and that the thermostat (26) and the
pressure switches (27,33) are provided with bellows being in contact
with the atmosphere so that it is possible to compensate for the chan-
ges in the atmospheric pressure automatically.

15 10. An apparatus according to any of claims 5-9, c h a r a c t e r -
i z e d in that a density regulator (68) or a conductivity meter (43)
is connected to the sump (3) for metering the density and the conduc-
tivity, respectively, of the polluted liquid (41), said density regu-
lator and said conductivity meter control the opening and closing of a
draining-off valve (42',19).

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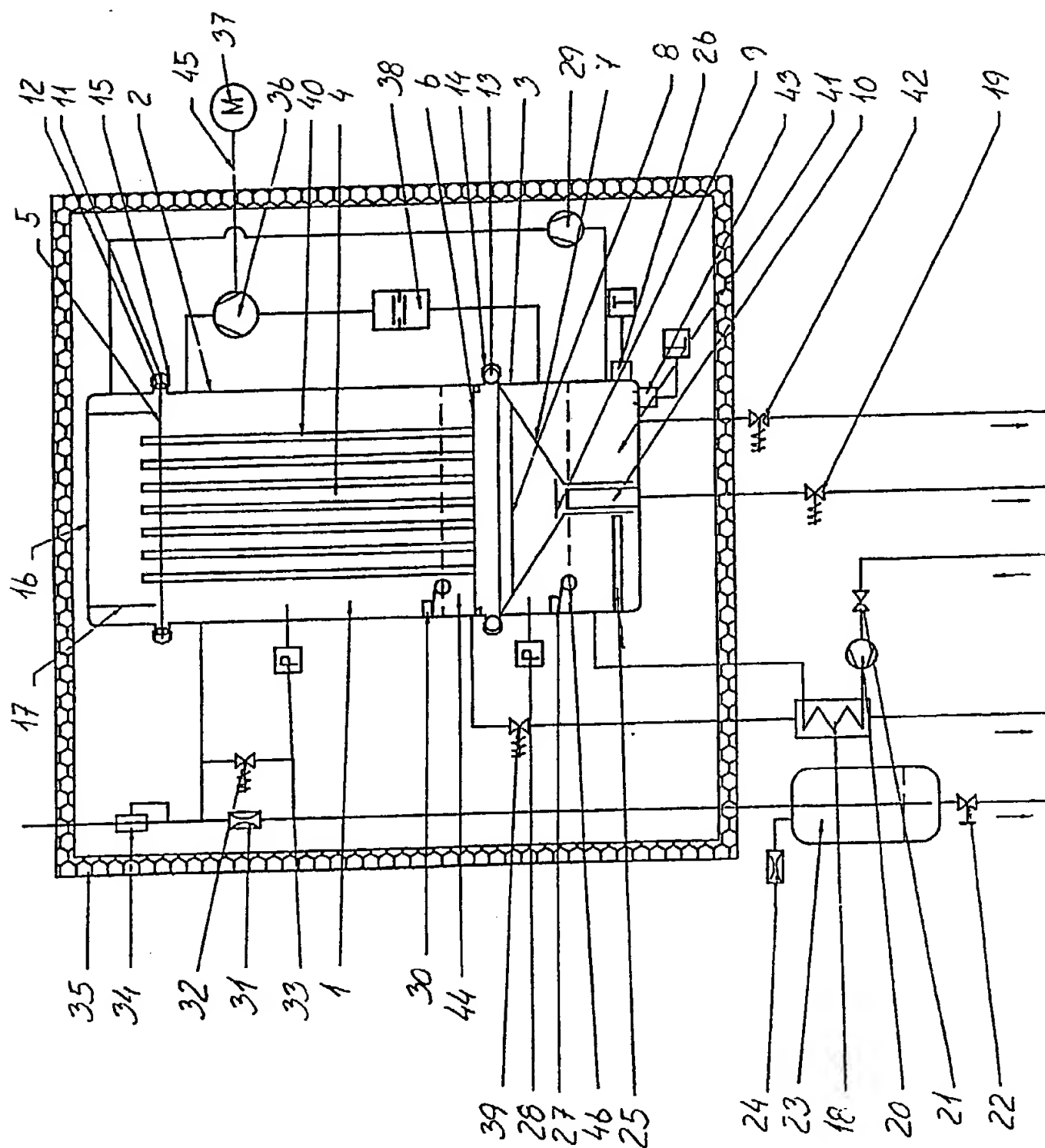
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FIG. 1



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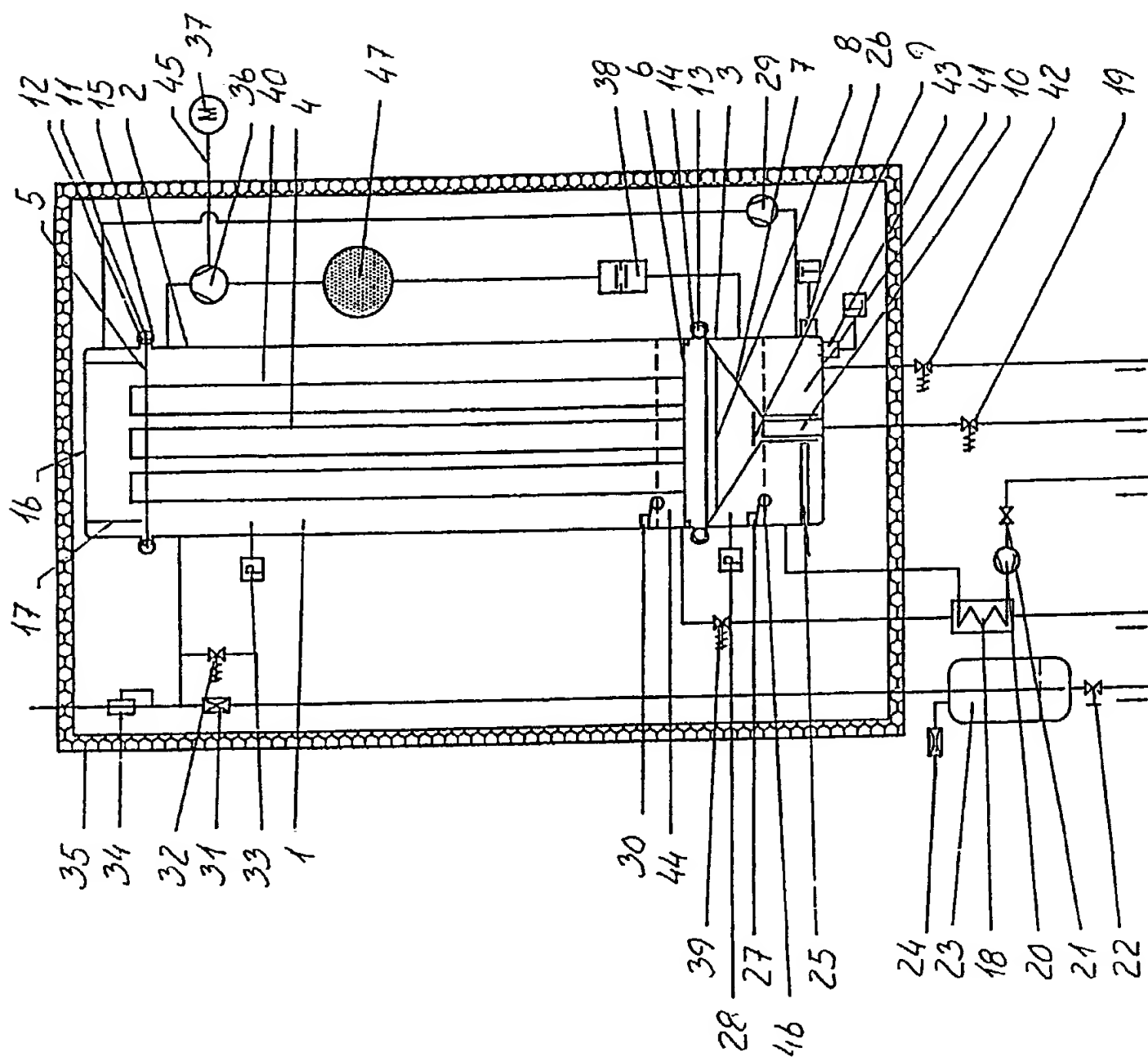
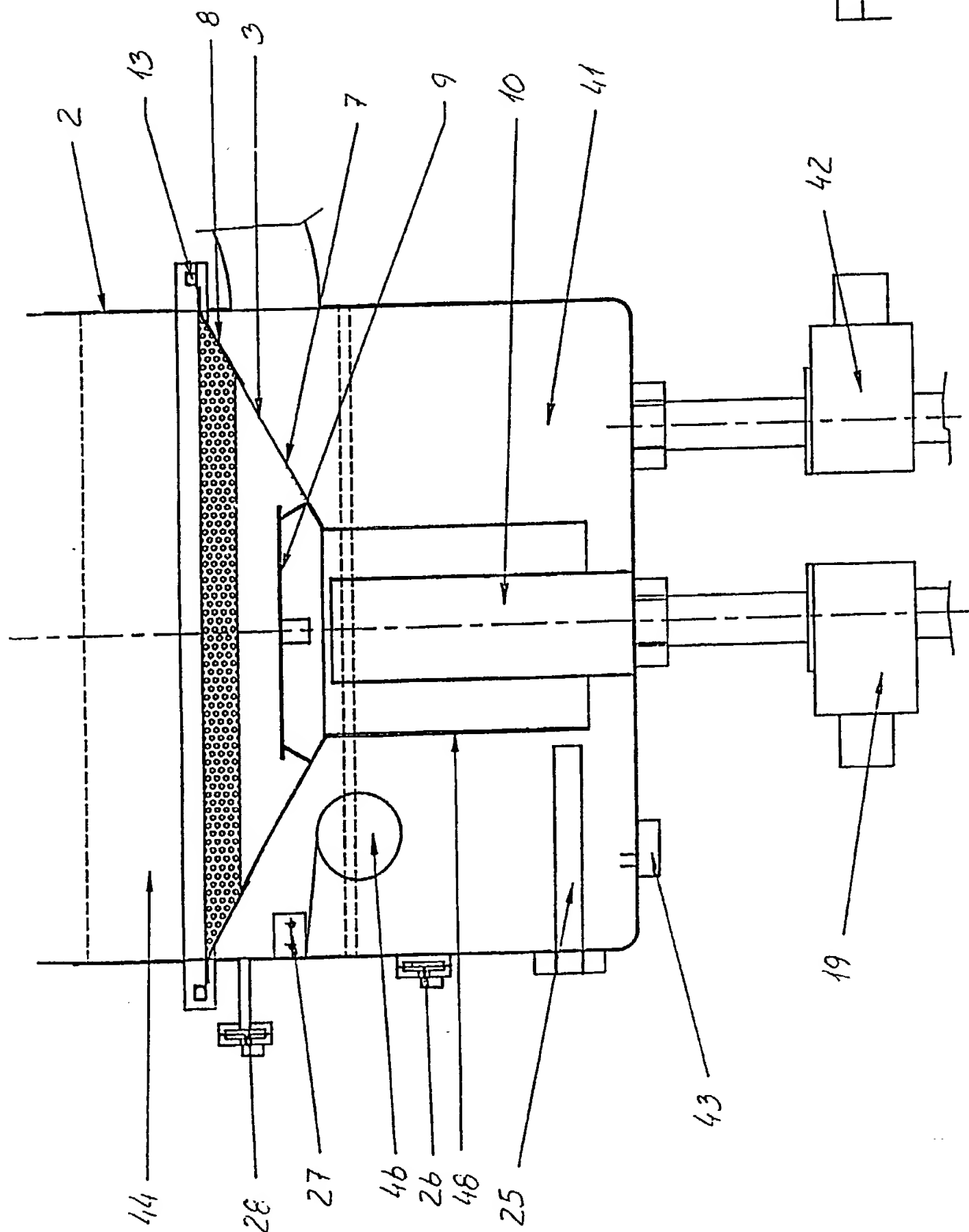


FIG. 2

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FIG. 3



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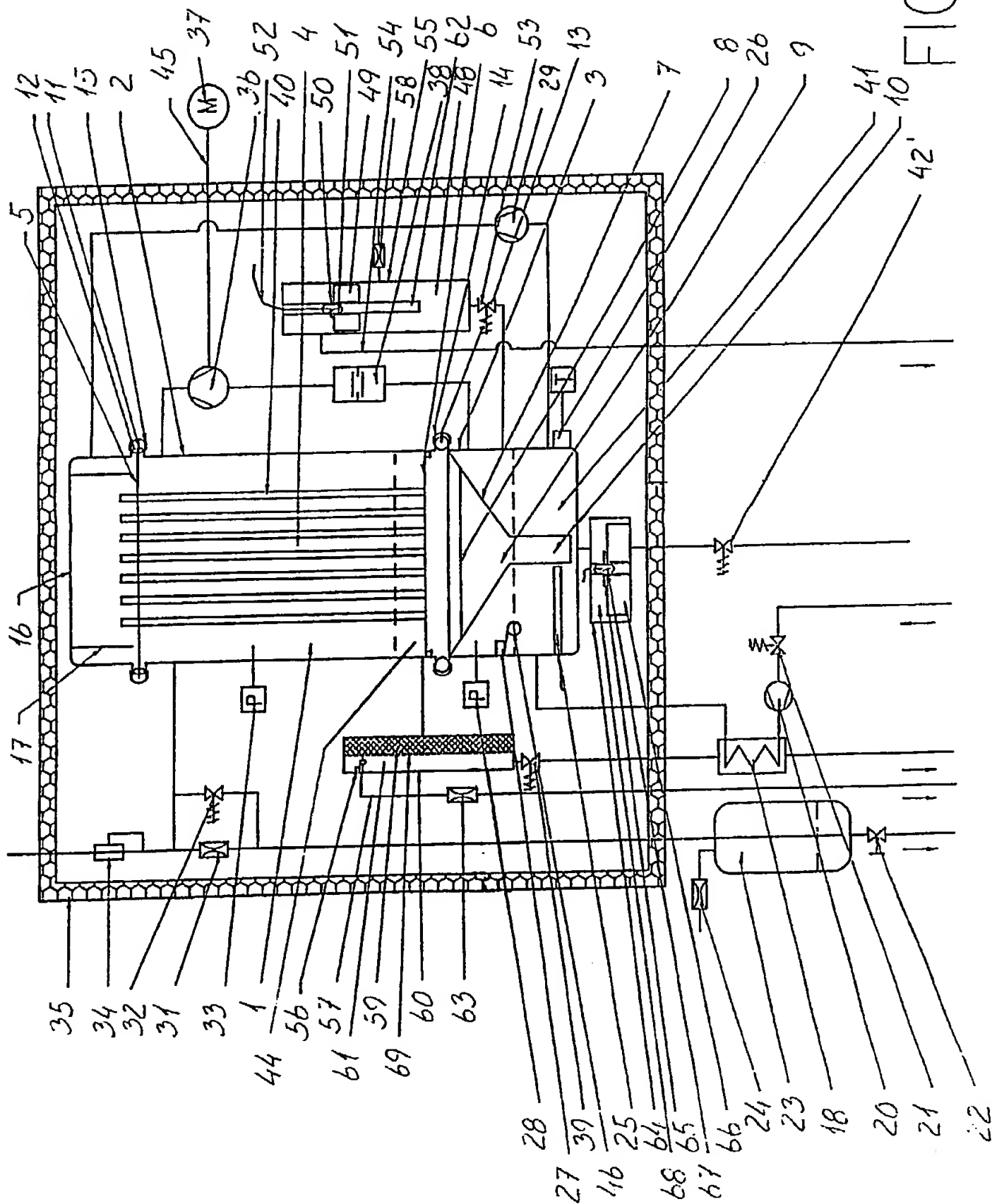
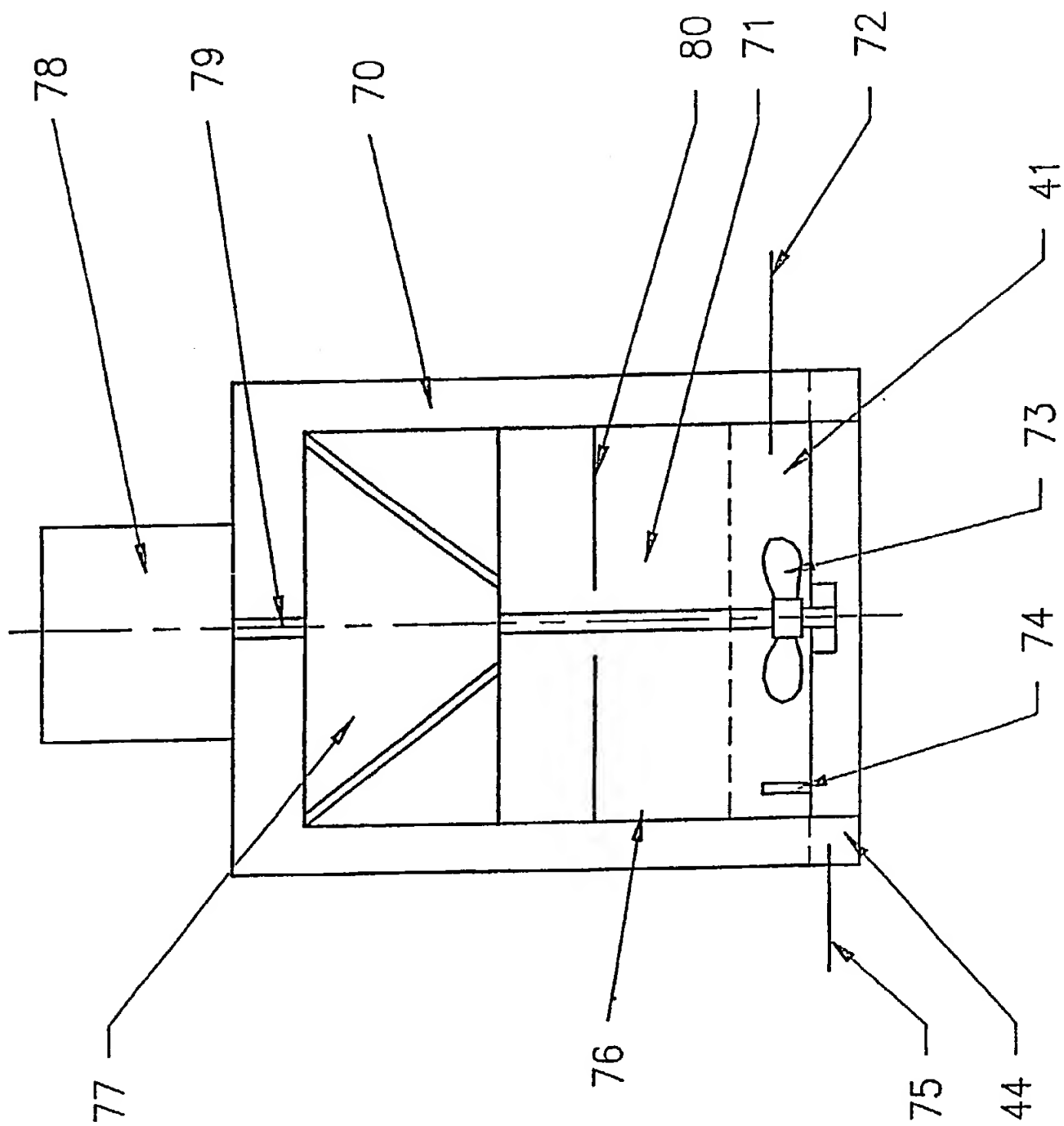


FIG. 4




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FIG. 5



INTERNATIONAL SEARCH REPORT

International Application No PCT/DK 91/00212

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) ⁶ According to International Patent Classification (IPC) or to both National Classification and IPC IPC5: B 01 D 1/28, C 02 F 1/04														
II. FIELDS SEARCHED <div style="text-align: center; border-top: 1px solid black; border-bottom: 1px solid black;">Minimum Documentation Searched⁷</div> <table style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 25%; border-bottom: 1px solid black;">Classification System</th> <th style="border-bottom: 1px solid black;">Classification Symbols</th> </tr> <tr> <td style="border: 1px solid black; height: 40px; vertical-align: bottom;">IPC5</td> <td style="border: 1px solid black; vertical-align: bottom;">B 01 D; C 02 F</td> </tr> </table> <div style="text-align: center; border-top: 1px solid black; border-bottom: 1px solid black;">Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in Fields Searched⁸</div> <p>SE,DK,FI,NO classes as above</p>			Classification System	Classification Symbols	IPC5	B 01 D; C 02 F								
Classification System	Classification Symbols													
IPC5	B 01 D; C 02 F													
III. DOCUMENTS CONSIDERED TO BE RELEVANT⁹ <table style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 10%; border-bottom: 1px solid black;">Category *</th> <th style="border-bottom: 1px solid black;">Citation of Document,¹¹ with indication, where appropriate, of the relevant passages¹²</th> <th style="width: 15%; border-bottom: 1px solid black;">Relevant to Claim No.¹³</th> </tr> <tr> <td style="border: 1px solid black; text-align: center; vertical-align: top;">Y</td> <td style="border: 1px solid black; vertical-align: top;">US, A, 2487884 (G.P. LUNT) 15 November 1949, see column 3, line 25 - line 46; column 4, line 49 - line 50; figure 1 --</td> <td style="border: 1px solid black; text-align: center; vertical-align: top;">1,2,4,5</td> </tr> <tr> <td style="border: 1px solid black; text-align: center; vertical-align: top;">Y</td> <td style="border: 1px solid black; vertical-align: top;">US, A, 4698136 (M. EL-ALLAWY) 6 October 1987, see column 4, line 4 - line 11; column 4, line 12 - line 28; column 5, line 13 - line 16; figure 1 --</td> <td style="border: 1px solid black; text-align: center; vertical-align: top;">1,2,4,5</td> </tr> <tr> <td style="border: 1px solid black; text-align: center; vertical-align: top;">A</td> <td style="border: 1px solid black; vertical-align: top;">EP, A2, 0237855 (METZGER, KLAUS) 23 September 1987, see column 4, line 10 - line 14; figures 3,4 --</td> <td style="border: 1px solid black; text-align: center; vertical-align: top;">4</td> </tr> </table>			Category *	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³	Y	US, A, 2487884 (G.P. LUNT) 15 November 1949, see column 3, line 25 - line 46; column 4, line 49 - line 50; figure 1 --	1,2,4,5	Y	US, A, 4698136 (M. EL-ALLAWY) 6 October 1987, see column 4, line 4 - line 11; column 4, line 12 - line 28; column 5, line 13 - line 16; figure 1 --	1,2,4,5	A	EP, A2, 0237855 (METZGER, KLAUS) 23 September 1987, see column 4, line 10 - line 14; figures 3,4 --	4
Category *	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³												
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A	EP, A2, 0237855 (METZGER, KLAUS) 23 September 1987, see column 4, line 10 - line 14; figures 3,4 --	4												
<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p>* Special categories of cited documents:¹⁰</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the International filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 45%;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance, the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance, the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&" document member of the same patent family</p> </div> </div>														
IV. CERTIFICATION <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; border-bottom: 1px solid black;">Date of the Actual Completion of the International Search</td> <td style="width: 50%; border-bottom: 1px solid black;">Date of Mailing of this International Search Report</td> </tr> <tr> <td style="border: 1px solid black; text-align: center;">13th November 1991</td> <td style="border: 1px solid black; text-align: center;">1991 -11- 25</td> </tr> <tr> <td style="border-bottom: 1px solid black;">International Searching Authority</td> <td style="border-bottom: 1px solid black;">Signature of Authorized Officer</td> </tr> <tr> <td style="border: 1px solid black; text-align: center;">SWEDISH PATENT OFFICE</td> <td style="border: 1px solid black; text-align: center;">  Bengt Christensson </td> </tr> </table>			Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	13th November 1991	1991 -11- 25	International Searching Authority	Signature of Authorized Officer	SWEDISH PATENT OFFICE	 Bengt Christensson				
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13th November 1991	1991 -11- 25													
International Searching Authority	Signature of Authorized Officer													
SWEDISH PATENT OFFICE	 Bengt Christensson													

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
A	DK, C, 78060 (ROLF ANDERSEN) 6 September 1954, see page 1, column 1, line 1 - line 11; page 1, column 2, line 13 - line 16; page 2, column 1, line 25 - line 30 --	1,5
A	SE, C, 84977 (LA DISTILLATION DYNAMIQUE) 3 December 1935, see page 2, column 1, line 4 - line 10 --	1,5
A	DE, C, 405912 (THE TECHNO-CHEMICAL-LABORATORIES) 11 November 1924, see claim 1 -- -----	1,5

**ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO.PCT/DK 91/00212**

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the Swedish Patent Office EDP file on **91-09-27**
The Swedish Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 2487884	49-11-15	NONE	
US-A- 4698136	87-10-06	CH-A-B- 664753 DE-A- 3419171 FR-A- 2564819 GB-A-B- 2159142 JP-A- 60257893 NL-A- 8501438	88-03-31 85-11-28 85-11-29 85-11-27 85-12-19 85-12-16
EP-A2- 0237855	87-09-23	DE-C- 3609180	87-09-03
DK-C- 78060	54-09-06	NONE	
SE-C- 84977	35-12-03	NONE	
DE-C- 405912	24-11-11	NONE	